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Stanford Project: PROTEAN Project

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The goals of this project are related both to biochemistry and artificial intelligence: (a) use existing AI methods to aid in the determination of the 3-dimensional structure of proteins in solution (not from x-ray crystallography proteins), and (b) use protein structure determination as a test problem for experiments with the AI problem-solving structure known as the Blackboard Model. Empirical data from nuclear magnetic resonance (NMR) and other sources may provide enough constraints on structural descriptions to allow protein chemists to bypass the laborious methods of crystallizing a protein and using X-ray crystallography to determine its structure. This problem exhibits considerable complexity, yet there is reason to believe that AI programs can be written that reason much as experts do to resolve these difficulties. A prototype knowledge-based system assembles major secondary structures of a protein into families of structures compatible with a given set of distance constraints under the control of an explicit assembly strategy. Structures can also be refined at the atomic level of detail using constraints within secondary structures and between amino acid side chains to further restrict the 3-dimensional structure found. By generalizing this approach to the assembly of arrangements of objects subject to constraints, we have developed a language for specifying actions and control for problem solving in similar problem domains.

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Stanford Project: RADIX -- DERIVING KNOWLEDGE FROM
TIME-ORIENTED CLINICAL DATABASES

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The objective of clinical database (DB) systems is to derive medical knowledge from the stored patient observations. However, the process of reliably deriving causal relationships has proven to be quite difficult because of the complexity of disease states and time relationships, strong sources of bias, and problems of missing and outlying data.

The first goal of the RADIX Project is to explore the usefulness of knowledge-based computational techniques in solving this problem of accurate knowledge inference from non-randomized, non-protocol patient records. Central to RADIX is a knowledge base (KB) of medicine and statistics, organized as a taxonomic tree consisting of frames with attached data and procedures. The KB is used to retrieve time-intervals of interest from the DB and to assist with the statistical analysis. Derived knowledge is incorporated automatically into the KB. The American Rheumatism Association DB containing records of 1700 patients is used.

The second goal of the project is to develop a program and set of techniques for automated summarization of patient records. The summarization program is designed to automatically create patient summaries of arbitrary and appropriate complexity as an aid for tasks such as clinical decision making, real-time patient monitoring, surveillance of quality of care, and eventually automated discovery. Two prototype summarization modules have been implemented in KEE on the Xerox 1108 workstation.

SOFTWARE AVAILABLE ON SUMEX

RADIX--(excluding the knowledge base and clinical database) consists of approximately 400 INTERLISP functions. The following groups of functions may be of interest apart from the RADIX environment:

SPSS Interface Package -- Functions which create SPSS source decks and read SPSS listings from within INTERLISP.

Statistical Tests in INTERLISP -- Translations of the Piezer-Pratt approximations for the T, F, and Chi-square tests into LISP.

Time-Oriented Data Base and Graphics Package -- Autonomous package for maintaining a time-oriented database and displaying labelled time-intervals.

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National AIM Project: CADUCEUS
(INTERNIST-I)

QMR
(Quick Medical Reference)

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The major goal of both the CADUCEUS and INTERNIST-I/QMR Projects is to produce a reliable and adequately complete diagnostic consultative program in the field of internal medicine. Although this program is intended primarily to aid skilled internists in complicated medical problems, the program may have spin-offs as a diagnostic and triage aid to physicians' assistants, rural health clinics, military medicine and space travel. In the design of INTERNIST-I and QMR, we have attempted to model the creative, problem-formulation aspect of the clinical reasoning process. The program employs a novel heuristic procedure that composes differential diagnoses, dynamically, on the basis of clinical evidence. During the course of a INTERNIST-1 consultation, it is not uncommon for a number of such conjectured problem foci to be proposed and investigated, with occasional major shifts taking place in the program's conceptualization of the task at hand. QMR is broader in scope than INTERNIST-I or CADUCEUS, in that it provides quick and efficient access to the INTERNIST-I/QMR knowledge base to provide low and intermediate level informational support for physicians' decision-making, in addition to providing consultative advice.

SOFTWARE AVAILABLE ON SUMEX

Versions of INTERNIST-I are available for experimental use, but the project continues to be oriented primarily towards research and development; hence, a stable production version of the system is not yet available for general use. QMR has been shared on a restricted basis with a limited number of academic colleagues, who have agreed to give the QMR development team feedback on the program's strengths and weaknesses.

National AIM Project: CLIPR -- HIERARCHICAL MODELS
OF HUMAN COGNITION

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The CLIPR Project is concerned with the modeling of complex psychological processes. It is comprised of two research groups. The prose comprehension group has completed a project that carries out the text analysis described by van Dijk & Kintsch (1983), yielding predictions of the recall and readability of that text by human subjects. The human-computer interaction group is developing a quantitative theory of that predicts learning, transfer, and performance for a wide range of computer-tasks, e.g. text editing, Kieras & Polson (1985).

SOFTWARE AVAILABLE ON SUMEX

A set of programs has been developed to perform the microstructure text analysis described in van Dijk & Kintsch (1983) and Kintsch & Greeno (1985). The program accepts a propositionalized text as input, and produces indices that can be used to estimate the text's recall and readability.

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National AIM Project: MENTOR -- MEDICAL EVALUATION OF
THERAPEUTIC ORDERS

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The goal of the MENTOR project is to implement and begin evaluation of a computer-based methodology for reducing therapeutic misadventures. The project uses an on-line expert system to continuously monitor the drug therapy of individual patients and generate specific warnings of potential and/or actual unintended effects of therapy. The appropriate patient information is automatically acquired through interfaces to a hospital information system. This data is monitored by a system that is capable of employing complex chains of reasoning to evaluate therapeutic decisions and arrive at valid conclusions in the context of all information available on the patient. The results reached by the system are fed back to the responsible physicians to assist future decision making.

Specific objectives of this project include:

1. Implement a prototype computer-based expert system to continuously monitor in-patient drug therapy that uses a modular medical knowledge base and a separate inference engine to apply the knowledge to specific situations.
2. Select a small number of important and frequently occurring drug therapy problems that can lead to therapeutic misadventures and construct a comprehensive knowledge base necessary to detect these situations.
3. Design and begin implementation of an evaluation of the prototype MENTOR system with respect to its impact on the on the physicians' therapeutic decision making as well as its effects on the patient in terms of specific mortality and morbidity measures.

The work in this project builds on the extensive previous work in drug monitoring done by these investigators in the Division of Clinical Pharmacology at Stanford and the University of Maryland School of Pharmacy.

National AIM Project: SOLVER -- PROBLEM SOLVING EXPERTISE

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The Minnesota SOLVER project focuses upon the development of strategies for discovering and representing the knowledge and skill of expert problem solvers. Although in the last fifteen years considerable progress has been made in synthesizing the expertise required for solving complex problems, most expert systems embody only a limited amount of expertise. What is still lacking is a theoretical framework capable of reducing dependence upon the expert's intuition or on the near exhaustive testing of possible organizations. Our methodology consists of: (1) extensive use of verbal thinking aloud protocols as a source of information from which to make inferences about underlying knowledge structures and processes; (2) development of computer models as a means of testing the adequacy of inferences derived from protocol studies; (3) testing and refinement of the cognitive models based upon the study of human and model performance in experimental settings. Currently, we are investigating problem-solving expertise in domains of medicine, computer hardware diagnosis, offline quality control, financial auditing, management, and law.

SOFTWARE AVAILABLE ON SUMEX

A redesigned version of the Diagnoser simulation model, named Galen, has been implemented on SUMEX. Galen is an expert system which uses recognition-based reasoning in pediatric cardiology.

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National AIM Project: ATTENDING Project:
A Critiquing Approach to
Expert Computer Advice

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Our project is exploring the "critiquing" approach to bringing computer-based advice to the practicing physician.

Critiquing is a different approach to the design of artificial intelligence based expert systems. Most medical expert systems attempt to simulate a physician's decision-making process. As a result, they have the clinical effect of trying to tell a physician what to do: how to practice medicine. In contrast, a critiquing system first asks the physician how he contemplates approaching his patient's care, and then critiques that plan. In the critique, the system discusses any risks or benefits of the proposed approach, and of any other approaches which might be preferred. It is anticipated that the critiquing approach may be particularly well suited for domains, like medicine, where decisions involve a great deal of *subjective* judgment.

To date, several prototype critiquing systems have been developed in different medical domains:

1. ATTENDING, the first system to implement the critiquing approach, critiques anesthetic management.
2. HT-ATTENDING critiques the pharmacologic management of essential hypertension.
3. VQ-ATTENDING critiques aspects of ventilator management.
4. PHEO-ATTENDING critiques the laboratory and radiologic workup of a patient for a suspected pheochromocytoma.
5. In addition, a domain-independent system, ESSENTIAL-ATTENDING, has been developed to facilitate the implementation of critiquing systems in other domains.

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Stanford Project: REFERENCE Project

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The goals of this project are related both to medical science and Artificial Intelligence: (a) use AI methods to allow the informed but non-expert reader of the medical literature to evaluate a randomized clinical trial, and (b) use the interpretation of the medical literature as a test problem for studies of knowledge acquisition and fusion of information from disparate sources. REFERENCE and REVIEWER, a planned extension, will be used to evaluate the medical literature of clinical trials to determine the quality of a clinical trial, make judgements on the efficacy of the treatment proposed, and synthesize rules of clinical practice. The research is an initial step toward a more general goal - building computer systems to help the clinician and medical scientist read the medical literature more critically and more rapidly.

National AIM Project: Computer-Aided Diagnosis of
Lymph Node Pathology (PATHFINDER)

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The PATHFINDER Project is centered on the construction of an expert system for assisting pathologists with the diagnosis of tissue pathology. PATHFINDER research is focused on the domain of lymph node pathology. The project is based at the University of Southern California in collaboration with the Stanford University Medical Computer Science Group. Ongoing AIM research has been addressing fundamental problems of knowledge representation, reasoning strategies, user modeling, explanation, and user acceptance. A pragmatic goal of the project is to provide a valuable diagnostic and educational tool for pathologists with different levels of training and experience by integrating diverse knowledge about lymph node pathology. It is hoped that PATHFINDER basic research on representation and inference in combination with the pragmatic goals of constructing a clinically-relevant diagnostic aid will lead to useful advances in medical computing.

A pilot version of the program provides diagnostic advice on eighty common benign and malignant diseases of the lymph nodes based on 150 histologic features. Our research plans are to develop a full-scale version of the computer program by substantially increasing the quantity and quality of knowledge and to develop techniques for knowledge representation and manipulation appropriate to this application area. The design of the program has been strongly influenced by the INTERNIST/CADUCEUS program developed on the SUMEX resource.

SOFTWARE AVAILABLE ON SUMEX

PATHFINDER-- A version of the PATHFINDER program is available for experimentation on the DEC 2060 computer. This version is a pilot version of the program, and therefore has not been completely tested.

AIM Pilot Project: RXDX Project

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We are developing a prototype expert system that could act as a consultant in the diagnosis and management of depression. Health professionals will interact with the program as they might with a human consultant, describing the patient, receiving advice, and asking the consultant about the rationale for each recommendation. The program uses a knowledge base constructed by encoding the clinical expertise of a skilled psychiatrist in a set of rules and other knowledge structures. It will use this knowledge base to decide on the most likely diagnosis (endogenous or nonendogenous depression), assess the need for hospitalization, and recommend specific somatic treatments when this is indicated (e.g., tricyclic antidepressants). The treatment recommendation will take into account the patient's diagnosis, age, concurrent illnesses, and concurrent treatments (drug interactions).

The potential benefits to psychiatry include: making relatively skilled psychiatric consultation widely available in underserved areas, including some public mental health facilities where patients are seen by non-psychiatrists and have relatively little direct patient-physician contact; providing non-psychiatrically trained physicians with additional information about psychiatric diagnosis and treatment; avoiding errors of oversight caused by inaccessible patient data; and increased productivity in patient care. Like any good consultant, the program will be able to teach the interested user, and can function as a teaching tool independent of direct clinical application.

PUBLICATIONS

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National AIM Project: DECISION SUPPORT FOR
 TIME-VARYING CLINICAL PROBLEMS

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Time-varying systems, which include many areas of medicine, science, economics, and business, can be described mathematically by differential equations. They are distinct from the pattern-matching and logic-based domains dealt with so successfully by existing expert system methods, because they can include feedback relationships. It is generally felt that they are best approached by enhancement of existing methods for deep model-based reasoning.

The goal of this project is to develop AI methods for capturing and using knowledge about time-varying systems. The strategy is to address general problems in model-based knowledge representation and reasoning. The intermediate objective is to develop methods which are powerful enough to work in selected realistic situations yet are general enough to be transportable to other, unrelated knowledge domains.

The tactical approach is to work on well-defined yet complex and interesting problems in the medical domain. We have, therefore, selected the human cardiovascular system as our prototype of a time-varying system, and are developing methods for representing and reasoning about its mechanical and electrical activities in the normal and diseased states.

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National AIM Project: KNOWLEDGE ENGINEERING FOR
 RADIATION THERAPY

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We are developing an expert system for planning of radiation therapy for head and neck cancers. The project will ultimately combine knowledge-based planning with numerical simulation of the radiation treatments. The numerical simulation is needed in order to determine if the proposed treatment will conform to the goals of the plan (required tumor dose, limiting dose to critical organs). The space of possible radiation treatments is numerically very large, making traditional search techniques impractical. Yet, with modern radiation therapy equipment, the design of treatment plans might be significantly aided by automatically generating plans that meet the treatment constraints. The project will result in systematization of knowledge about radiation treatment design, and will also provide an example of how to represent and solve design problems with a knowledge based system.

This project has some relevance to computer science as well, in that our approach, if successful, may contribute to a better understanding of design problem solving with knowledge-based systems.

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AIM Pilot Project: COMPUTER-BASED EXERCISES IN
 PATHOPHYSIOLOGIC DIAGNOSIS

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Research in artificial intelligence at Dartmouth Medical School focuses on three main areas: 1) knowledge-based systems applied to laboratory medicine and pathology, 2) knowledge acquisition using machine learning techniques, and 3) computer-based instruction using artificial intelligence techniques to critique students' workup plans. These projects have in common the fundamental research questions of how knowledge should be represented and used in a classification approach to problem-solving related to the use of laboratory data.

An interdisciplinary team of computer scientists, physicians, and educators is working on the Computer-based Exercises project. A prototype system is nearing completion, with formative evaluation scheduled for Fall, 1987.

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